in the Museum of Science and Art, Edinburgh, is based upon Bartholomew's map of Edinburgh on the scale of 15 inches to a mile, but the altitudes are taken point by point from the large town plans of the Ordnance Survey. The model is in many ways original in its mode of construction. Its object is purely geographical, having been suggested by a leading citizen as a method of showing the contrast between the circuitous roads and frequent steep gradients of the old coaching days, and the straighter and more level lines of communication by which modern engineers have overcome the restraint of physical configuration.

IN the same number of the *Scottish Geographical Magazine* there is a paper on the Deserts of Atacama and Tarapaca, read to the Society by Mrs. Lilly Grove, and some interesting notes on South Eastern Alaska by Prof. J. J. Stevenson, illustrated by a map.

MR. H. J. MACKINDER'S third educational lecture for the Royal Geographical Society was given on Friday night, the subject being the belt of Steppe which traverses Asia from west to east. He showed how the distinctive physical and climatic conditions of the Steppe favoured the growth of nomadic nations, every man of whom was a member of the most mobile cavalry force which ever existed. Pastoral pursuits and marauding were natural to the Steppe peoples, and the descent of their hordes on the settlements bordering the Steppe were turning-points in the history of surrounding nations. Reference to the successive periods of conquest by the Scythians, Huns, Turks, and Mongols showed the power of these nomads on the affairs of other countries, and until the advent of the Steppe-bred Cossacks no western power has ever secured control of the central Asian plains.

FOLLOWING on the death of Captain Stairs we have to record the death of his fellow-officer in the Emin relief expedition, Mr. R. H. Nelson. Mr. Nelson returned to Africa, and was in charge of the district of Kikuyu in Ibea, when he succumbed to an attack of dysentery on December 26, 1892.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE first general meeting for this year of the Institution of Mechanical Engineers was held on Thursday and Friday evenings of last week, the 2nd and 3rd inst., in the theatre of the Institution of Civil Engineers.

There were two papers set down for reading, as follows:—"Description of the experimental apparatus and shaping machine for ship models at the Admiralty Experimental Works, Haslar," by R. Edmund Froude, of Haslar; "Description of the pumping-engines and water-softening machinery at the Southampton Waterworks," by William Matthews, waterworks engineer.

After the disposal of the usual formal business, the President (Dr. William Anderson) referred to the International Engineering Congress which was to be held in Chicago during the month of August next. He had received a letter from Mr. James Dredge, of London, who had been elected honorary president of the congress. Every one, Dr. Anderson said, knew of Mr. Dredge, so there was no occasion for him to say anything further on that head; but he trusted that English engineers would take steps necessary to a creditable representation.

The next business was an alteration in the bye-laws, the chief referring to the class of membership. Hitherto the institution has consisted of members, associates, and graduates. The two latter classes are, however, of small importance and practically the institution is composed of full members. The qualification for membership was that the candidate should be an engineer not under twenty four years of age; so that a member might be a Great George Street magnate, or the head of a big engineering firm, down to a draughtsman or the foreman of a machine shop, supposing of course he were an engineer and not simply a mechanic or artisan. These conditions of equality do not appear, however, to meet the views of the council of the institution, so there are to be two classes of engineers on the register, the big and the little. These are to be known respectively as members and associate members, but as far as we can see the broad distinction is that the member has achieved success whilst the associate member has still his way to make. Honour to whom honour is due is a good maxim, but it may be doubted whether the practically self-elected council of an irresponsible body should be the arbiters, not only of fame, but of professional status.

Resolutions embodying the proposed changes were moved from the chair, and carried unanimously. It need not be said that the new rule is not retrospective.

These matters having been settled, the secretary proceeded to read Mr. Froude's paper describing the apparatus in the Haslar establishment, over which he presides. To make clear the details of mechanism given would be quite impossible without the aid of drawings. These were supplied at the meeting in the shape of wall diagrams, but as members had not an opportunity of studying them beforehand, there were very few who were able to keep up with the reading of the paper, excepting those who already knew all about the matter. This is too often—we may say generally—the case in meetings of the technical societies; excepting always the Institution of Civil Engineers. Before this Society a paper is read on one evening, and, if its importance be sufficient, it is discussed during three sittings, each a week apart. Members have therefore an opportunity of grasping the details of the papers read, and preparing what they have to say beforehand. It is for this reason that the discussions before the Civil Engineers have always been instructive.

Mr. Froude's paper deals with but a fragment of its subject, but it takes the part which was more especially of interest to his audience, namely, the mechanical details involved in the apparatus used for testing the models by which a forecast is made of the performance of future naval vessels. It is well known that these forecasts are made possible by the late Mr. Froude's discovery of the law of "corresponding speeds," so that the speed, with a given power, of the full-sized ship can be deduced from the performance of the model. The way in which the late Mr. Froude carried out his investigations, and how the original experimental works grew up at Torquay, under the wise encouragement of the Admiralty, are well known to all interested in physical science. It would be difficult to overestimate the good that has followed this work; for one thing it has done much to put us on an equality with our old rivals, the French—long, indeed, our masters in the science of ship design. Perhaps there is nothing upon which we could better found our claim to naval supremacy—in this long era of naval peace—than the possession of the only naval testing tank of its kind. It is a distinction we shall probably not long be able to boast, for the Russians, Italians, and Americans all contemplate constructing establishments of a like nature.

The paper commences with describing the principal features of the present Admiralty experiment establishment at Haslar. As at the former works at Torquay, the chief object consists of a long covered water-way, in which models of ships are towed to ascertain their resistance. The towing is done from a dynamometer carriage driven at definite speeds by a stationary engine working a wire rope. The models are made of hard paraffine, generally about 14 feet long, and something upwards of 1 inch in thickness as finished. They are cast in a mould with an allowance of about $\frac{1}{4}''$ for finishing the shape. The latter operation is done by hand, guidance grooves being cut in the model, so that the exact form may be preserved. The working of this shaping or copying machine, and the way in which it enables the lines of a drawing to be translated into model form, constitute one of the most interesting parts of the installation. The water-way, canal, or tank at Haslar is nearly 400 feet long, and of nearly uniform section throughout. The sides are of concrete and vertical, and the railway, on which the dynamometer carriage runs, is bedded on the tops of the side walls of the water-way, in place of being suspended over the water from the roof, as in the original design. The experimental carriage, which has to be nearly 21 feet gauge, is a trussed structure. Its principal peculiarity consists in the fact that the members of the several trusses composing it are wooden trunks or boxes about 4" square in cross sections, made of $\frac{3}{8}''$ deal, and put together with screws and shellac varnish. At the joints formed by the intersection of the various members of the trusses, the sides of the boxes are made to overlap one another over a large area, providing a large surface for screwing and for the adhesion of the shellac varnish. The dimensions of the boxes forming the several members of the girders are designed so as to bring the sides of the boxes into the right planes to suit these overlaps. The whole structure thus provided is remarkably rigid and light. The general design of the carriage is arranged so as to leave clear a sort of central alley provided with a railway, the rails of which are close to the sides

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of the alley. The object of this secondary railway is to carry the smaller carriages, on which are mounted the actual experimental apparatus of different kinds; so that these may be adjusted on this railway to any desired position fore and aft on the main carriage. The carriage is driven by means of wire rope from a stationary 10″ Tower spherical engine, a high power being required so as to start the truck quickly for high speed experiments. The ordinary speeds range between 100 and 500 feet per minute; for some classes of models experiments are occasionally made up to about 850 feet per minute or nine and a half miles per hour. The truck has been run at over 1200 feet per minute, or about fourteen miles per hour. The governor, by which the speed of the engine is regulated, is a very interesting and ingenious piece of mechanism, which has been modified from the design of that which was used on the engine at Torquay. There are two symmetrical bell-cranks carrying weights, and attached to each other by links, having slotted holes so as to allow the bell-cranks to have a very small range of freedom of angular motion. When a given speed of rotation is reached, the centrifugal force of the weights overcomes the tension of a spiral spring, provided for the purpose, and the governing action is brought into play in the following manner:—There is a hooked rod, by means of which the increase in the angular altitude of the weights (due to centrifugal force) brings a friction disc break into play, which in turn has the effect of extending a spiral spring connected with the engine throttle valve, which is thus closed so as to shut off steam. It will be easily seen how much more delicate an adjustment this device gives than the old Watt governor with the balls acting directly on the valve. The extension of the spring, and the consequent distance of departure of the throttle valve from its full open position are proportional to the frictional turning movement applied to the stationary wheel, which movement is itself proportional to the pressure brought to bear upon it by the bell-cranks; in other words it is proportional to the excess of the speed above that at which the centrifugal force of the weights just equals the tension of the spiral spring. To give greater sensitiveness of action the bell-cranks are not hung on pin joints but on flat springs after the fashion of a clock pendulum, safeguards being provided in case of the springs breaking. With the Torquay governor, which was similar in principle to that described, although differing in appearance, the adjustment was so delicate that a variation of speed in the running of the carriage of half a foot per minute was seldom exceeded even at the highest speeds. The value of working against the resistance of spiral springs will be noticed in this mechanism, their steadying action being especially valuable. It would be impossible for us to attempt to describe the mechanism constituting the copying apparatus of the model shaping machine, and we can only hope to give a mere outline of the general principles. A rough hollow model of the ship to be constructed is cast in paraffine wax, a material which is found to lend itself most perfectly to the necessities of the experiments. The drawing from which the operator has to work is stretched on a table, and the grooves representing the water lines are copied from the drawing by means of the mechanism. These grooves are formed by a pair of revolving cutters, the fore and aft motion being communicated to the model whilst the cutters move laterally. One cutter is on each side—for of course full models are required—and they approach or recede symmetrically in such accordance with the longitudinal travel of the model as to trace in plan upon it the intended horizontal section. This due accordance of the lateral motion of the cutters with the longitudinal motion of the model is accomplished by the operator so regulating the cutter motion as to maintain a tracer in contact with the corresponding water-line on the drawing. By suitable mechanism the drawing itself is made to imitate the longitudinal travel of the model, while the tracer imitates the lateral travel of the cutters. In the Torquay machine the tracer was guided by an adjustable template set to the curve of each water-line, but afterwards the tracer was made to follow the line on the drawing by the operator. In the present machine the cutters are raised or lowered to get the different water-lines. The cutters run at 2700 revolutions per minute. The grooves having been cut, the surplus material is removed by hand.

We shall not follow Mr. Froude in his description of the further details of the mechanism, as it would be unintelligible without the drawings by which he illustrated his description. The various arrangements are, however, fully worthy of study by all who are interested in ingenious mechanical devices; but we must refer our readers to the printed transactions of the institution, in which the diagrams will appear when the volume is published. There is also a weighing machine, which is necessary to obtain the actual dead weight of the model, so that the amount of ballast required to get the necessary displacement corresponding to trial draught may be determined. This machine will weigh up to 1000 lbs. with great accuracy, and is similar in principle to an ordinary chemical balance, except that it is a steel yard, having one arm 6 inches and the other 5 feet in length.

The discussion on this paper was opened by Mr. W. H. White, the Director of Naval Construction, who is the official head of the Admiralty department, of which the Haslar establishment forms a branch. Mr. White spoke of the advantage these model experiments had been to the navy, saying that the great advance in the speed of ships which had been obtained of late years would not have been reached to the full extent had it not been for the model experiments carried out at Torquay and Haslar by the late Mr. Froude and his son, the author of the paper. Mr. J. I. Thornycroft also pointed out the great economy that had been made in expenditure upon navy ships by finding out beforehand what the proposed vessel would do, and what was required in the way of power to reach that performance. Mr. Thornycroft made especial reference to the ingenuity of the device whereby a line on the drawing, which might not be quite accurate, would be made to give the desired result in the model, and this without an expensively-constructed apparatus. Various other speakers having been heard, and Mr. Froude having briefly replied, so far as there was anything to reply to, the meeting adjourned until the next evening.

On the members assembling on Friday evening, the 3rd inst., the president, Dr. Anderson, again occupied the chair, and Mr. Matthews's paper on the Southampton waterworks was read. This contribution is interesting, as it describes what we understand is the largest water-softening plant yet installed. The quantity of water that can be satisfactorily dealt with is from 2¼ to 2½ million gallons per day of 24 hours. Of course the principle of softening hard water by lime is very far from new, but it has made slow progress, in spite of the vast quantities of hard water, otherwise unobjectionable, that there are in the chalky southern half of our island. This limited application of a means whereby a bad water in one respect can be made a good one in all respects does not appear, to judge by the proceedings of last Friday, to spring from any inherent defect in the system—beyond that which would arise from the disposal of the refuse lime in crowded cities—but rather from the carelessness of public authorities and water-supplying companies to the wants and comforts of the people at large.

The meeting terminated with the usual votes of thanks, the President announcing that the summer meeting would be held this year at Middlesborough on Tuesday, August 1, and the following days.

THE SEVEN IMAGES OF THE HUMAN EYE.

IT is well known that in the human eye, besides the refracted image, which serves the purposes of vision, there are formed three reflected images known under the name of "Purkinje's images." M. Tcherning has discovered three additional ones, so that the total number is brought up to seven.[1]

In its passage into the interior of the eye each ray of light has to pass through the cornea, the aqueous humour, the crystalline lens, and the vitreous humour before finally arriving at the retina. At the surface of each of these constituents the ray is liable to be partially reflected, thus giving rise to four reflected images. These were all seen and described by Purkinje at the beginning of the century, but only three were observed by Helmholtz and others. These three can be easily observed by two persons on holding a lighted match between their eyes, and moving it about so that the reflections seem to come from the pupil. One of them, that reflected by the front of the cornea, is much brighter than the two others, which are formed by the front surfaces of the crystalline and the vitreous humour respectively. The fourth image is due to reflection from the posterior surface of the cornea. It may be discovered by careful observation of the brightest image by means of a magnifying glass. As

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[1] See *Séances de la Société Française de Physique*, Avril-Novembre, 1892.

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